Uncertainty Analysis of California Streamflow Using Multiple Climate Change Scenarios

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RESEARCH OBJECTIVES

The objectives of this study are to determine the potential upper and lower bounds of future streamflow response in California, based on a range of climate projections.

APPROACH

Analysis of the range of hydrological response is based on two Global Climate Model (GCM) projections: the Hadley Centre's HadCM2, a warm and wet projection; and the National Center for Atmospheric Research Parallel Climate Model (PCM–B06.06), a cool and dry projection. Three future periods (2010–2039, 2050–2079, 2080–2099) were analyzed. Future watershed mean-area temperature (precipitation) sensitivities were derived from the temperature (precipitation) difference (ratio) between the projected and baseline (1961 to 1990) climatologies. Specified perturbations with increasing temperature (T) and precipitation (P) were also used. Hydrology was simulated using the Sacramento Soil Moisture Accounting Model, for a set of representative basins (Smith, Sacramento, Feather, American, Merced, Kings).

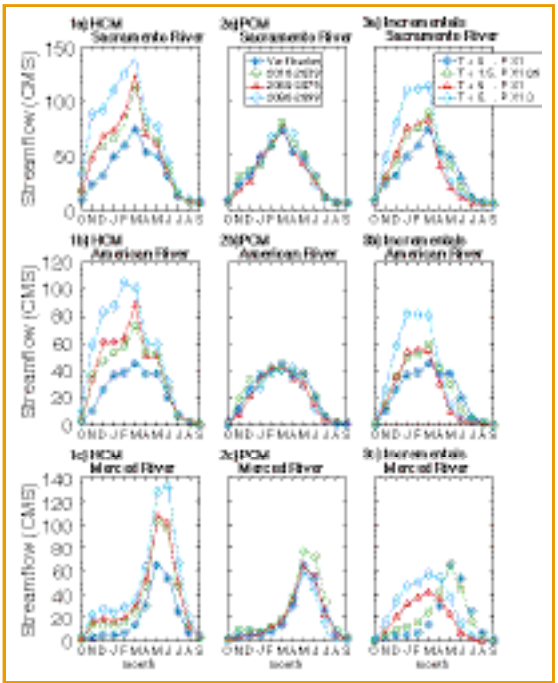

Figure 1. Climatological monthly streamflow at the (a) Sacramento, (b) American, and (c) Merced watersheds for GCM projections: (1) warm-wet and (2) cool-dry. Incremental temperature (0° to 5°C) and precipitation (0.7 to 1.30 %) are specified for each watershed as well.

ACCOMPLISHMENTS

Streamflow was analyzed with historical and HadCM2- and PCM-perturbed time series, and specified increments (see Figure 1). During 2010–2039, HadCM2-forced peakflow occurs during the same month with increased peakflow magnitude for the Sacramento (1a), American (1b), and Merced (1c). Peakflow timing during the 2080–2099 period for the American is a month, while the Sacramento timing remains unchanged. The higher elevation Merced has peakflow one month later than the historical, and a secondary peakflow. This secondary high flow results from increased early season snowmelt and a higher snowline, caused by increased temperature.

The relatively cool-dry PCM-forced streamflow significantly decreases during the March-to-July melt season. Peakflow remains close to the historical amount for the Sacramento (2a) and American (2b) for all projected periods, but the Merced (2c) shows an increase during 2010–2039, and then decreases during 2050–2079 and 2080–2099. For these projections, the American shows a peakflow one month earlier, while the timing of the other two watersheds remains consistent with the historical peakflow timing.

The uniform perturbations bracket projected temperature uncertainties. The 1.5°C increase and 9% precipitation increase do not change peakflow timing, but increase the October to February peakflow magnitude and slightly decrease the magnitude during the snowmelt period. The peakflow magnitude is higher for the Sacramento (3a) and American (3b), but not for the high-elevation Merced (3c). The Merced peakflow decreases and occurs three months earlier. The extreme scenario represents a high likelihood of more flood events and decreased snowmelt runoff.

SIGNIFICANCE OF FINDINGS

California Sierra Nevada peakflow will likely occur earlier and with increased magnitude. Summer season flow will likely decrease. High-elevation basins are less sensitive to warming, but show a peakflow shift under the incremental changes. The range of outcomes suggests that peakflow magnitudes can shift from 100% increases to 50% decreases.

These results have been applied to water demand and agro-economic analyses (Brekke et al. 2003).

RELATED PUBLICATIONS

Brekke, L.D., N.W.T. Quinn, N.L. Miller, and J.A. Dracup, Climate Change Impacts Uncertainty for San Joaquin River Basin. J. American Water Resources Association (in press), Berkeley Lab Report LBNL-51393, 2003.

Miller, N.L., K.E. Bashford, and E. Strem, Potential impacts of climate change to California hydrology. LBNL-51313, J. American Water Resources Association, August 2003.

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